

### **REMARKS**

Claims 28-43 are pending. Claims 1-27 have either been canceled in prior papers or are canceled in this paper. No new matter is added. Favorable consideration of the currently pending claims is respectfully requested in light of the foregoing amendments and following remarks.

#### ***Support for New Claims***

New independent Claim 28 is based on cancelled Claim 1 but now includes the limitation that the reaction conditions provide for a polymer growth of a continuous, reactive coating on a surface of the substrate. Support for Claim 28 is found in the specification at page 11, lines 27 to 28, where it is explained that XPS analysis of the coating shows no Si (2p) peak.

New dependent Claim 29 includes the feature that the pulsed plasma discharge is applied in a single ON-OFF sequence. Support for this limitation is found in the specification at Example 1 and in the description at page 6, lines 18 to 20, where it is explained that the exemplified sequence is typical.

New dependent Claims 30 and 31 refer to the period in which the pulsed plasma discharge is applied. Support for these limitations can be found at page 6, lines 5 to 6 of the specification.

New independent Claim 32 particularly points out a selection in both compound and average power density as the efficient way to a continuous polymer coating containing surface reactive surface epoxy groups. It includes an additional limitation that the continuous coating is obtained within a period of from 30 seconds to 20 minutes. Support for this limitation can be found in the present Examples and at page 9, lines 11 to 14 and page 11, lines 25 to 26 of the specification. Support for the additional feature is also found as explained above with respect to Claims 30 and 31. Support for new dependent Claim 33 is the same as that of Claim 29.

New independent Claim 34 is similar to new independent Claim 32 and includes the additional limitation that the continuous coating is obtained by a pulse discharge applied in a single ON-OFF sequence. Support for this limitation is explained above with respect to Claim 29. Support for new dependent Claim 35 can be found at page 6, line 6 of the specification.

New dependent Claim 36 is similar to new independent Claim 32 except that it requires the additional limitation of Claim 34. Support for Claim 36 is the same as that of Claim 34.

New dependent Claims 37-39 are dependent on Claims 29, 33 and 36, respectively, and include the limitation that the single ON-OFF sequence includes an OFF time of at least 10000  $\mu$ s. Support for this limitation can be found at page 5, lines 6 to 8 and page 6, lines 12 to 19 of the specification.

New dependent Claims 40 and 41 refer to the product of reaction of the surface functionalized substrate with trifluoroacetic acid vapor or with a solution of diethylamine in methanol. Support for these claims can be found in Example 2 and, in particular, the passage in the description at page 14, line 15 and page 15, line 5 of the specification.

New dependent Claims 42 and 43 correspond to canceled Claims 12 and 21, and support for these claims can be found therein.

***Rejections Under 35 U.S.C. § 103:***

In the Office Action, the Examiner rejected the then-pending claims under 35 U.S.C. § 103(a) as obvious over Connell *et al.* (UK 1,037,144) (“Connell”) in view of Timmons *et al.* (5,876,753) (“Timmons”) or vice versa. In addition, the Examiner rejected the claims under 35 U.S.C. § 103(a) as obvious over Timmons in view of Kolluri *et al.* (5,723,219) (“Kolluri”), and Timmons in view of Chabreck *et al.* (WO 98/28026)

(“Chabrecek”). Applicants respectfully submit that the new claims are allowable in view of the remarks presented below.

Applicants have previously argued that a meaningful comparison between the present application and Timmons is possible and that the Examples **do** fall within the scope of the claims and further that the claimed invention is not obvious because it is surprising that low powers could lead to such a high level of reactive epoxide groups in the polymer coating.

Applicants have also filed a Declaration by Dr Stephen Coulson, an expert in the technical field of the claimed invention, which provides data concerning the claimed plasma polymerization of glycidyl methacrylate (GMA) and confirms that the reactor volume used for the present Examples is 470 cm<sup>3</sup>. Dr Coulson further states that he finds the polymerization surprising in view of Example 1 of Timmons and Examples 4 and 5 of the present application, because the average power density is so very low as to go beyond that which would be achieved by mere routine experimentation.

Applicants assert that the claimed method is novel and nonobvious over the cited references because the present application teaches an efficient method for forming a continuous reactive coating containing a high density of epoxide group. Even if the claimed average power density is not unique to the present application, applicants submit that the claimed average power density has not previously been applied to the specifically claimed monomer or indeed to any epoxy-containing monomer.

Moreover, it is clear from the present application that the use of such low power densities with this specific monomer leads to unexpected advantages in terms of the nature of the coating and the efficiency with which it may be deposited. In particular, the coating is **continuous** and has a high epoxy group content (as shown in Examples 1 and 3) and it is formed **within 15 minutes** as compared to 30 minutes and much lower epoxide group content (shown by Examples 4 and 5) with an alternative epoxy-containing monomer

suggested in the art. The coating obtained using the present invention also has remarkable adhesive properties (shown by Example 3).

All of the rejections in the Office Action rely on rely upon Timmons' disclosure of plasma polymerization of monomers using a pulsed plasma discharge. The rejections are based on three essential points:

- (1) that a true comparison of the claimed invention with the disclosure of Timmons is not possible because neither the application or Timmons disclose effective reactor volumes;
- (2) that the Examples of the present application are not commensurate with the scope of the claimed invention; and
- (3) that the claimed invention is obvious from the general teaching of Timmons when seen in the light of certain other references.

Applicants will address these points in turn.

***(1) The Comparison of Timmons to the Claimed Invention***

Applicants now submit newly found documents (listed in an Information Disclosure Statement/PTO SB/08 filed concurrently herewith) which show that the effective volume of the Timmons reactor was 943 cm<sup>3</sup>.

Applicants refer first to the Timmons publication, "Plasma Synthesis of a Novel CF<sub>3</sub>-Dominated Fluorocarbon Film" in *Chem. Mater.* 1996, 8, 2212-2214. It discloses the work that appears in Example 9 of the Timmons reference and refers to two documents describing previous studies undertaken by Timmons relating to pulsed plasma synthesis of fluorocarbon films.

The two documents are "Molecular Surface Tailoring of Biomaterials Via Pulsed RF Plasma Discharges" in *J. Biomater. Soc., Polym. Ed.* 1993, 5, 131 and "Molecular Tailoring of Surfaces Via Pulsed RF Plasma Depositions" in *J. Appl. Polym. Sci: Appl. Polym. Symp.* 1994, 54, 123.

It can be expected that the data of Example 9 would have been generated from this apparatus because the Timmons publications are contemporaneous with the Timmons reference.

Each of these documents discloses a reactor for carrying out plasma polymerization of fluorocarbons or other monomers (Figure 1). The reactor is described in both of the referenced documents as a 10 cm diameter, 30.5 cm long Pyrex glass cylinder, and Figure 1 shows a distance between electrodes of 12 cm. It is clear that the effective plasma volume of the reactor is the volume of the cylinder between the electrodes.

The volume of a cylinder is calculated from the formula  $V = \pi r^2 l$  where  $r$  is the radius and  $l$  is the length of the cylinder. And so the effective plasma volume of the reactor is

$$V_{\text{eff}} = 3.141 \times (10/2 \text{ cm})^2 \times 12 \text{ cm} = 943 \text{ cm}^3$$

Applicants thus believe that with the knowledge that the relevant volume of the reactor used by Timmons reference was  $943 \text{ cm}^3$ , a true comparison between the claimed average power densities and the average power densities disclosed in the Timmons reference can be made.

The comparison considers that the effective plasma volume of a reactor can be referred to as the effective volume and that the average effective power density can be referred to as the average power density. It also considers that the average power density takes into account the duty cycle which is employed for the pulsed plasma polymerization.

The average power density has been the subject of some confusion and it has been said by the Examiner that the reference to “the average power of the pulsed plasma discharge is low, for example less than  $0.05 \text{ W/cm}^3$ ” at page 6, lines 10 to 11 of the specification is in fact a reference to average power density but only during the period in which the power is ON.

Applicants believe, however, that the person of ordinary skill in the art understands that this is a reference to average power density that includes the period in

which the power is OFF and that it can be determined according to the well known formula mentioned at column 8 of the Timmons reference.

Such a view is consistent with the explanation that immediately follows at page 6, lines 14 to 15 of the specification that “the pulsing regime which will deliver such low average power discharges will vary ..”.

The present Examples report plasma polymerizations undertaken with allyl glycidyl ether (AGE), glycidyl methacrylate (GMA) and butadiene monoxide (BM). They **all** show plasma polymerizations in which a **low** power has been employed and each compares the results of plasma polymerization using a plasma generated by exposure to a continuous radiofrequency wave and a plasma generated by exposure to a pulsed radiofrequency wave.

The comparison also considers that an experiment in which the plasma is generated by exposure to a continuous radiofrequency wave can be referred to as a continuous wave (CW) experiment, and that an experiment in which the plasma is generated by exposure to a pulsed radiofrequency wave can be referred to a pulsed experiment.

The reactor volume of  $470\text{ cm}^3$  mentioned by Dr Coulson is the effective reactor volume for the apparatus used by applicants and the average power density of each CW experiment can be seen to be  $3\text{ W} / 470\text{ cm}^3 = \mathbf{0.0064\text{ W/cm}^3}$ .

The average power of each pulsed experiment can be seen to be  $40\text{ W} \times (20\text{ }\mu\text{s} / 20020\text{ }\mu\text{s}) = 0.04\text{ W}$  so that the average power density is  $0.04\text{ W} / 470\text{ cm}^3 = \mathbf{0.000085\text{ W/cm}^3}$ .

Applicants note that the Timmons reference does not actually exemplify deposition of **any** epoxy-containing monomer. There is no teaching of the precise conditions that Timmons would employ for the AGE monomer. It is only possible to **speculate** on the appropriate power conditions on the basis of the power conditions used in the Examples.

The average power density of Timmons Example 1, in which allyl bromide is deposited, varies because what he reports is a pulsed experiment in which a variable duty cycle is used.

If it is accepted that the reactor volume is  $943 \text{ cm}^3$  and the lowest duty cycle for each Example is considered, it can be seen that the lowest average power is  $200 \text{ W} \times (3 \text{ ms}/63 \text{ ms}) = 9.5 \text{ W}$  and the lowest average power density is  $9.5 \text{ W}/943 \text{ cm}^3 = 0.01 \text{ W/cm}^3$ . Applicants submit that this low level is used only at the end of a variable duty cycle in which significantly higher power densities have previously been applied.

The Examiner has pointed out that Example 5 reports a series of experiments in which the lowest average power according to Figure 8, is  $25 \text{ W} \times (10 \text{ } \mu\text{s}/1010 \text{ } \mu\text{s}) = 0.25 \text{ W}$ . The lowest average power density is  $0.25 \text{ W}/943 \text{ cm}^3 = 0.00027 \text{ W/cm}^3$  and Example 5 can be considered to describe a pulsed experiment in which the average power density is below that which is claimed, *i.e.*, that  $0.00027 \text{ W/cm}^3$  is lower than  $0.0025 \text{ W/cm}^3$ . Example 5, however, is only intended to demonstrate that functional group retention (in this case the C(O)Cl group) is better at lower powers. **The general teaching of Timmons remains that such a low average power density is to be applied at the end of a variable duty cycle (see claim 1) in which significantly higher power densities have previously been applied.**

***(2) The Claimed Invention is Commensurate in Scope to the Examples***

The analysis described above reveals that each of the Examples of the present application describe a pulsed experiment in which the average power density is below that which is claimed, *i.e.*, that  $0.000085 \text{ W/cm}^3$  is **lower** than  $0.0025 \text{ W/cm}^3$ .

It is also clear that the average power density of the CW experiment in each Example is higher than that which is claimed, *i.e.*, that  $0.0064 \text{ W/cm}^3$  is **higher** than  $0.0025 \text{ W/cm}^3$ .

***(3) The Claimed Invention is Not Obvious in View of Timmons and the Other Cited References***

**The Timmons Disclosure**

Applicants return to the question of whether Timmons discloses or suggests low power plasma polymerization of specifically AGE, and whether such disclosure or suggestion means that the claimed low power plasma polymerization of GMA is obvious.

Applicants submit that there is **nothing** in any Example or description by Timmons which shows low power plasma polymerization of AGE. Timmons only **suggests** that his teaching can be applied to AGE when he mentions allyl and other compounds and points out AGE as one of the possible allyl compounds.

This is exemplified by Timmons' disclosure that "obviously this technology can be extended to include a rich and diverse range of additional functional groups" and that "the following list of allyl type compounds represents a partial listing of additional functional groups which could be deposited as intact entities for further chemical derivatizations."

Applicants believe that it is not correct to consider such statements as constituting actual disclosure of a pulsed plasma polymerization of AGE at low power, because it is simply not credible that the Timmons method can be applied to all of the compounds he mentions.

Moreover, it is well established in chemistry that no two chemical compounds necessarily behave alike, and that consequently their reactivity in any given circumstance cannot be predicted or relied upon.

It is stressed that applicants have shown in low power experiments (present Example 4) that AGE is wholly unsatisfactory **in spite of the fact that Timmons suggests that it would be successful.**



In this regard, applicants note that the Examples of the present application do not compare high and low power experiments. Applicants stress that **both** the CW and pulsed experiments are **low power** plasma polymerizations.

In relation to Example 4, the average power density of the CW experiment is  $0.0064 \text{ W/cm}^3$ , which is lower than the average power density that can be derived for the pulsed plasma polymerization of allyl bromide in Timmons' Example 1 ( $0.01 \text{ W/cm}^3$ ).

The experimental data from the CW experiment shows that the incorporation of epoxide into the developed surface film is **wholly unsatisfactory** because it leads to almost total loss of the epoxide group (see Fig. 8b of the present application).

Applicants believe that this could be due to a rearrangement product arising from a series of radical reactions involving initial H-atom abstraction at the epoxide ring and subsequent relief of ring strain by epoxide ring opening. In any case, it is clear from Example 4 that, even under these low power conditions, **a continuous coating which retains epoxy groups is not obtained.**

As explained above, the average power density of the pulsed experiment is  $0.000085 \text{ W/cm}^3$ , which is **lower** than the average power density for the pulsed plasma polymerization in Timmons' Example 1 ( $0.01 \text{ W/cm}^3$ ) and Timmons' Example 5 ( $0.00027 \text{ W/cm}^3$ ).

Again, the experimental data shows that the incorporation of epoxide groups into the developed surface coating is **wholly unsatisfactory** because it does not lead to a continuous coating within a reasonable reaction time.

In addition, epoxy groups are not retained within the coating even under these extremely low power (as is seen by the disappearance of the epoxy peak from the IR spectrum shown in Fig. 8c).

Example 4 evidences, therefore, that chemical reactivity in similar chemical compounds cannot be reliably predicted and that the behavior of the compound Timmons

actually deposits (allyl bromide) and the compound which he suggests (AGE) is quite different in low power plasma polymerization.

Present Example 5 evidences the same when it reports that low power plasma polymerization of butadiene monoxide is also unsatisfactory.

Applicants submit, therefore, that all that should be taken from Timmons is that pulsed plasma polymerization of AGE at low power may be worth attempting.

In this regard, it is mentioned that Timmons considers (at column 12, lines 50 to 55) that the “film” term “may, but does not necessarily, mean an intact film in the usual sense” and goes on to suggest that the term may just describe “more widely dispersed non-interacting pendant groups.”.

### **The use of GMA**

The Examiner appears to consider it obvious to substitute the monomer suggested by Timmons with another which is suggested from the other cited references to be used in plasma polymerization and that, having done so, it is mere routine experimentation to find suitable low power plasma conditions.

Applicants submit that it is not obvious to substitute the monomer suggested by Timmons for GMA **if it cannot be predicted that the substitute will work in the way that is suggested for the monomer.**

The Examiner makes much of the fact that GMA and AGE are mentioned together in other cited references as possible monomers for plasma polymerization. But the most that can be taken from these references is that the monomers are considered to behave in a similar way for the purpose and general power conditions reported therein.

It is not correct to find that they will behave in the same way in such a novel method as that reported by Timmons. Applicants have shown that such a conclusion is not justified – **at least because the monomer suggested by Timmons does not itself work satisfactorily.**

Moreover, it is noted that Connell discloses plasma polymerization of ethylenically unsaturated monomers by providing a glow discharge in a vapor of the monomer by subjecting the vapor simultaneously to a radiofrequency electric field and to a magnetic field. Connell does not, however, aim to produce a continuous polymer coating in which a reactive functional group from a monomer is preserved – Connell only attempts to form a film for use as a dielectric layer for electrical insulation purposes.

Kolluri discloses surface functionalization in which a polymer network has been built up by sequential plasma polymerization of certain monomers. But there is no exemplification of any plasma polymerization with **any** epoxy monomer – only a **notional** example of a plasma polymerization of GMA (Formula 19) followed by plasma polymerization of a diamine followed by plasma polymerization of GMA and so on.

Moreover, Kolluri is not really concerned with incorporation of high levels of epoxide groups by deposition of a continuous polymer coating with optimal retention of epoxide groups because such high levels are given by cross-linking with a diamine which is also laid down by a plasma polymerization process.

Although Chabreck is concerned with the preservation of epoxide group during plasma polymerization of GMA, he relies upon a completely different technique as compared to that of Timmons. Example B-5 shows a “plasma induced” polymerization which comprises firstly remote exposure of the substrate to a plasma generated from argon gas followed by remote exposure to a plasma generated from a mixture of argon gas and GMA and secondly, flooding the substrate with GMA vapor. The Examiner states that the after-glow polymerization equates with polymerization during the OFF time of an in-glow pulsed plasma polymerization. But that does not mean that the technique shown by Chabreck is equivalent to an in-glow polymerization. Chabreck himself points out a **significant difference** when he says that the polymer film of an in-glow polymerization suffers from **undesirable surface erosion** and cross-linking resulting from the direct exposure of the film to the plasma.

The particular suitability of GMA for providing a continuous, reactive coating containing reactive epoxy groups by low power plasma polymerization cannot, therefore, be deduced from Chabracek.

Applicants add that the art mentioned to be of interest does not add any support for the Examiner's view that GMA and AGE can be used equivalently for plasma polymerization at relatively low power for similar reasons.

Applicants further submit that the use of GMA cannot be considered to be obvious for the following additional reasons. It is Timmons that must be considered as the most likely starting point for arriving at the claimed invention. The other references do not provide a convincing starting point for the reasons which are apparent from the discussion above.

In view of this, **a person of ordinary skill would not choose anything other than the monomer (AGE) suggested by Timmons.** He would not naturally choose another monomer because Timmons appears to him to suggest a **complete solution** on how to obtain polymer coatings incorporating high levels of epoxide groups, which can be subsequently derivatized, by plasma polymerization of AGE at low power. There is thus **no reason to combine** Timmons with any of the other cited references. *See KSR International Co. v. Teleflex* and MPEP § 2141.

The Examiner considers that such an argument is not logical, but applicants submit that this is what is fairly suggested by Timmons in the absence of hindsight. Nevertheless, if a person of ordinary skill in the art would turn to other, unspecified monomers when he found that the method failed for AGE or for some other reason, he would find that the literature reveals a large number of ethylenically unsaturated epoxides, and not just GMA, which could be equally considered as candidate monomers.

A review of the cited references alone reveals other ethylenically unsaturated epoxy monomers such as glycidyl isopropylether, glycidyl butyrate, 3-glycidoxy-

propyltrimethoxysilane (Kolluri), glycidyl vinyl ether, butadiene monoxide (Kokaku) and divinylbenzene monoxide (Taguchi).

And if the person of ordinary skill chose butadiene monoxide, he would also find that the method did not work. Example 5 of the present application shows that plasma polymerization of butadiene monoxide at low power is also **wholly unsatisfactory** because either the epoxide group is lost or the polymerization becomes too slow.

Applicants add that the claimed average power densities do not reflect mere routine experimentation in adjusting power parameters for GMA because they **unexpectedly** lead to a **continuous, reactive polymer coating containing reactive surface epoxy groups**.

In this regard, it is emphasized that Timmons does not give any clear guidance as to the particular power conditions to be applied to a particular ethylenically unsaturated epoxy monomers in order to obtain such a coating. The person of ordinary skill is simply left to his own devices to gauge and develop suitable conditions for obtaining a continuous polymer coating from that monomer.

It is also surprising that the claimed average power densities for GMA should provide continuous coatings with very high levels of epoxy group functionality (about 96% according to Table I in the application as originally filed).

Such a result **cannot be expected** because as explained above it cannot be predicted that different ethylenically unsaturated epoxy monomers behave in the same way during low power plasma polymerization.

### **Other Claim Limitations**

It is further **surprising** that the continuous, reactive polymer coating can be obtained in such a short time (30 seconds to 20 minutes) and especially surprising in view of Timmons that it shows very good adherence to polyethylene (as shown in present

Example 3) when it is obtained by applying a plasma discharge in a single ON-OFF sequence.

Moreover, although Timmons does disclose a series of experiments at constant duty cycle (Example 5), Timmons teaches that good adherence of the polymer film **requires a variable duty cycle** starting at much higher average power densities.

In sum, applicants submit that the presently claimed method makes a novel and nonobvious contribution to the art in identifying an incomplete teaching and directing the person of ordinary skill on how to obtain continuous reactive polymer coatings having high levels of reactive surface epoxy groups.

It is further submitted that the Examiner's rejection of the claims in view of Timmons and the other cited references demonstrates a clear example of hindsight reconstruction. Applicants respectfully request that the Examiner consider what the person of ordinary skill would really have taken from Timmons and whether he would really have selected another compound over AGE. If so, would he have chosen GMA over other ethylenically unsaturated epoxy monomers? And how could he really know that he would obtain a continuous reactive polymer coating at such low powers—even when he applied a plasma discharge at constant rate and kept the reaction time short?

For at least the reasons discussed above, applicants submit that the present claims are novel and nonobvious over the prior art cited in the Office Action, and applicants respectfully request that new claims 28-43 be given favorable consideration.

### **CONCLUSION**

Based upon the amendments and remarks provided above, applicants believe that Claims 28-43 are in condition for allowance. A Notice of Allowance is therefore respectfully solicited.

No additional fees are believed due; however, the Commissioner is hereby authorized to charge any additional fees that may be required, or credit any overpayment, to Deposit Account No. 11-0855.

If the Examiner believes any informalities remain in the application that may be corrected by Examiner's Amendment, or there are any other issues that can be resolved by telephone interview, a telephone call to the undersigned attorney at (404) 815-6500 is respectfully solicited.

Respectfully submitted,

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